[0007] However, in the vapor extraction methods, the pump and treat methods and the like, facilities must be separately provided at the site to render the pollutants harmless after the aforementioned drawing or pumping. Therefore, the treatment cost is increased.

[0008] In the methods in which the excavated soil is thermally destructed at high temperatures and the like, a large-scale facility is required for the heat treatment of the soil. Furthermore, since soil particles themselves deteriorate due to heat, and functions of, for example, growing living organisms, which are inherent in the soil, are substantially degraded, it is difficult to reuse the soil after the treatment.

[0009] The bioremediation method cannot be applied to all soil because the soil at each site has different characteristics. Even when it is applied, reactions proceed slowly since they rely on the function of microbes and the method requires a long treatment time and, therefore, has poor usefulness in practice.

[0010] As a method which might overcome the aforementioned problems of conventional measures against the pollutions, various methods, in which halogenated hydrocarbons as pollutants are contacted with iron functioning as a reducing agent to render them harmless by dehalogenation, have been suggested and have attracted attention.

[0011] For example, Japanese Unexamined Patent Application Publication (Tokuhyo) No. 5-501520 (WO91/08176) describes a method in which a channel is dug in a flow path of groundwater and filled with iron in the form of particles, slices, fibers, or the like. Subsequently, the iron is contacted with the halogenated hydrocarbons which cause pollution of the groundwater to dehalogenate and render the halogenated hydrocarbons harmless. The iron used in that process is not necessarily specifically prepared and, therefore, generates waste during the steps of cutting metals or low purityiron powders such as iron powders are generated during the steps of casting iron and the like.

[0012] A method similar to the aforementioned method, in which halogenated

hydrocarbons contained in the groundwater as pollutants are rendered harmless by using metal iron mixed with activated carbon, is described in Japanese Unexamined Patent Application Publication (Tokuhyo) No. 6-506631 (WO92/19556).

[0013] Japanese Unexamined Patent Application Publication (Tokukai) No. 11-235577 discloses a method in which chlorinated organic compounds contained in the soil above the level of groundwater or the excavated soil is contacted with an iron powder and rendered harmless by dechlorination. The iron powder used in this method must have a C content of 0.1% or more and a specific surface area of 0.05 m^2/g or more. Further, this iron powder must have such a particle size that 50% by weight or more of the iron powder passes through sieve openings of 150μm. A spongy iron-ore-reduced iron powder has been recommended for such an iron powder.

[0014] International Patent Publication WO 97/04868 describes a method in which a mixed metal produced by precipitating at least one metal selected from the group consisting of Cu, Co, Ni, Mo, Bi, Sn, Pb, Ag, Cr, Pd, Pt and Au on an iron powder is contacted with an aqueous composition polluted with halogenated hydrocarbons, and the halogenated hydrocarbons are dehalogenated and, therefore, the aqueous composition is remedied.

[0015] Each of the aforementioned methods, in which halogenated hydrocarbons as pollutants are contacted with iron functioning as a reducing agent and rendered harmless by dehalogenation, has a cost advantage and, therefore, is superior to conventional measures against the polluted soil and the polluted groundwater.

[0016] However, the iron used in the aforementioned methods may not be optimized for the aforementioned purposes and uses and, therefore, there has been a problem in that halogenated hydrocarbons cannot always be destroyed at a sufficient speed.

[0017] On the other hand, the method disclosed in International Patent Publication WO 97/04868 is intended to improve the speed of dehalogenation of the halogenated

The media/soil atmosphere may be aerobic or anaerobic. The pH of the media/soil is preferably within 1 to 10. When groundwater is remediated, the concentration of dissolved oxygen in the groundwater is not specifically limited and, therefore, the invention can be applied over a wide range.

[0058] The halogenated hydrocarbons contained in the media, soil, water, and gas undergo a dehalogenation reaction by contact with the iron powder for remediation according to the invention, and are decomposed into harmless compounds containing no halogen elements and hydrogen halides. For example, TCE receives an electron (be reduced) from the surface of the iron powder, and forms an unstable intermediate, for example, chloroacetylene, by β-elimination. Furthermore, the resulting intermediate is decomposed into compounds not containing chlorine, for example, acetylene. Sometimes, further reactions occur, although at all events, the dehalogenation reaction proceeds by the reception of the electron (be reduced) from the surface of the iron powder and, as a result, decomposition into harmless compounds proceeds.

(Examples)

[0059] The invention will be described below using Examples, although the invention is not limited to those.

(Examples 1 to 4)

(i) Preparation of iron powder for dehalogenation

[0060] An as atomized powder was produced from a molten steel at 1700° C by a water atomization process. Subsequently, finish reduction was performed in a stream of hydrogen at 900° C for 1 hour, and then, pulverization and adjustment of particle diameter were performed. The components in the iron powder at this stage were examined with the result that the contents of the primary components other than iron contained in the iron powder were as described below.

[Table 1]

Sample	Iron powder for dehalogenation		Halogenated hydrocarbon destruction test [1]	
	Particle diameter (amount of powder passed through 75 μm sieve) (%by mass)	Metal compound covering rate [2] (% by area)	Soil	Ground-water
Example 1	60% by mass or more	TiN 5	0.05	0.06
2	60% by mass or more	TiN 10	0.01	0.02
3	60% by mass or more	TiN 30	0.02	0.01
4	60% by mass or more	TiN 60	0.10	0.20
Comparative example 1	60% by mass or more	0	0.99	0.98
Example 5	60% by mass or more	TiO 5	0.20	0.30
6	60% by mass or more	TiO 10	0.03	0.05
7	60% by mass or more	TiO 30	0.02	0.03
8	60% by mass or more	TiO 60	0.70	0.80
Comparative example 2	60% by mass or more	TiO_2 10	0.97	0.98

1) Ratio of TCE concentration of sample to TCE concentration of reference sample after test for 3 days

2) Electric resistivity TiN 2.17×10^{-7} Ω·m
TiO 3×10^{-6} Ω·m
TiO_2 1.2×10^{2} Ω·m

(Examples 9 to 12)

[0071] An iron powder for remediation was prepared in a manner similar to those in Examples 1 to 4 by using a V_2O_3 powder (electric resistivity ρ: 1×10^{-5} Ω·m) instead of the TiN powder, and the destruction test of the halogenated hydrocarbons in the soil and the destruction test of trichloroethylene in the groundwater were carried out. The results are shown in Table 2.

destruction test of the halogenated hydrocarbons in the groundwater were carried out in a manner similar to that in Example 1. The results of the destruction tests and measurements are shown in Table 1.

(Comparative example 2)

[0074] An iron powder having a TiO_2 powder covering rate of 10% by area was prepared using a TiO_2 powder (electric resistivity ρ: 1.2×10^2 Ω·m) having an electric resistivity greater than 1×10^{-4} Ω·m instead of the TiN powder. Thereafter, the destruction test of the halogenated hydrocarbons in the soil and the destruction test of the halogenated hydrocarbons in the groundwater were carried out in a manner similar to that in Example 1. The results of the destruction tests and measurements are shown in Table 1.

[0075] When the inorganic compound is not present on the iron powder (Comparative example 1), or the inorganic compound (TiO_2) having an electric resistivity greater than about 1×10^{-4} Ω·m is present on the iron powder (Comparative example 2), the speed of destruction is low and, therefore, the trichloroethylene concentrations are hardly decreased after testing for 3 days. On the other hand, decreases in the concentration are clearly observed when an inorganic compound having an electric resistivity of about 1×10^{-4} Ω·m or less (TiN: electric resistivity ρ $= 2.17 \times 10^{-7}$ Ω·m, TiO: electric resistivity ρ $= 3 \times 10^{-6}$ Ω·m, or V_2O_3: electric resistivity ρ $= 1 \times 10^{-5}$ Ω·m) is present on the iron powder for remediation according to the invention (Examples 1 to 12).

[0076] The iron powder for remediation according to the invention has an unexpectedly and remarkably increased dehalogenation speed of halogenated hydrocarbons. There is no fear of the problem of secondary pollution due to metals contained in the iron powder, and the iron powder of the invention can be inexpensively produced. Furthermore, the iron powder of the invention can be applied to conventional methods, in which iron powders are used to render the polluted soil, groundwater and the like, containing halogenated